SUPPLEMENTAL AMENDMENT TO DISCLOSURE

Please amend the disclosure as set out below. ***No new material is being added.*** *A complete amended text is herewith submitted. It includes the following changes:*

1) *An editing to more clearly incorporate and unify the present text with that of the 1974 disclosure, part of which was edited out in earlier amendments, in response to the examiners's rejection of claim 349.*

2) *An explanation of the term "adiabatic", used to describe less-cooled engines about twenty years ago;*

3) *A clarification of how efficiency was given in the text; various other minor clarifications and corrections;*

4) *A brief explanation of blow-by related matters. Readers of US patent 7 117 827, a parallel disclosure, have indicated that they did not fully understand these.*

5) *Inclusion of additional disclosure on suitable materials for the invention, previously edited out of the 1974 text.*

6) *Correction of typographical and similar errors; (None so far.)*

IN THE TEXT:

Please amend the second paragraph of page 2 as follows: (Clarification.)

To the knowledge of the applicant, un-cooled engines are not in production today. Manufacturers and researchers tried to build what they called "adiabatic" semi-un-cooled engines in the late 1980's and (~~earlier~~) early 1990's. Publications indicate the work nearly all involved substituting ceramic materials for metals in key combustion chamber components. For example, ceramic caps were placed on metal pistons; ceramic liners placed in metal engine blocks; a zirconia poppet valve was substituted for an identically shaped metal valve. The work was not very successful for a number of reasons, including problems with differential thermal expansion of ceramic and metal components abutting each other. Engine designs were essentially unchanged.

Please amend the first full paragraph of page 3 as follows: (Clarification.)

In today's typical engine, roughly one third of the calorific value of the burnt fuel is put to work driving the piston, one third is dissipated via the cooling system and general radiation by the engine components and one third is carried away by the exhaust gases. The latest large diesels for trucks and marine applications have efficiencies in the 40 % range, but the average for all engines now operating

is close to 30 %. <u>These figures are for efficiencies on the piston crown, for new engines, in the optimum operating mode. Real-world efficiencies at the output shaft for all engines in the field, under all operating conditions, are far, far lower.</u> Current large engines, as used in ships and electricity generating stations, often have some form of compounding, which entails using a device (say a turbine) to derive further work from the hot exhaust gases.

Please amend the second full paragraph of page 3 as follows: (Clarification.)

In un-cooled engines, the combustion process takes place at higher temperatures, leading to efficiency increases of anywhere between 0 and 20 %, dependant on design and construction details. A (~~reasonable~~) <u>conservative</u> projection could be 10 %, enough to make to make a substantial difference to the oil needs and political situation of a country such as the USA. In compounded un-cooled engines greater efficiencies can be expected, since the exhaust energy conversion devices have a greater portion of the fuel's calorific value to work with - somewhere between 50 and 60 % could be in the hot exhaust gas. Turbines or steam engines may be used to extract work from the hot gas; optionally the gas heat can be converted into electrical energy. (~~At their present stage of development, heat to electrical energy devices have very approximately 25 % efficiency.~~)

Please delete the last paragraph of page 3. The paragraph dates from 1974, and is essentially being repositioned with other 1974 portions at the beginning of the disclosure, after the schedule of diagrams.

Please add, at the beginning of the disclosure section on page 8, the following lightly edited and updated text portions from 1974: (No new material has been added; the editing is for clarification and to reflect more recent calculations.)

It is considered perhaps the most important advantage of the invention that it offers an exceptional scope for fuel conservation. The principles of the invention relate also to methods of saving substantial further energy, by means of deriving further mechanical work from the combustion of a given amount of fuel and / or by means of the provision of energy storage in accumulators, so as to compensate for the stop / go nature of most vehicle operation. One such method is to raise the ambient temperature in an exhaust emissions reactor to substantially over the 950° to 1200°Centigrade (C) range, thereby further assisting the desired process of reaction, and to substanstially substantial increase the temperature in the combustion volume, thereby increasing the thermal efficiency of the engine. Another method involves the extraction of heat from the area of, or adjacent to at least the rear of an exhaust emissions reactor to provide further work. Further, the invention may be used in association with means of converting the flow of exhaust gas into mechanical energy.

In a conventional internal combustion engine (IC Engine), the rapid burning of the combustion charge in the confined space of the combustion volume produces expansion and heat. The expansion drives the piston and consequently engine while the heat product of the cycle is almost wholly unused - in fact considered undesirable since efforts are made to dissipate it as effectively as possible, by

means of conduction through cylinder walls and head to cooling system. Other heat is collected by the lubrication system to be often dissipated by oil radiators, sump cooling fins, etc.

A very rough approximation of the potential energy saving follows. Actual saving will vary widely, depending on engine size, state of tune and application. Let it be assumed that in a particular water-cooled engine the energy produced by the combustion or fuel is distributed as 32 % going to useful work on the piston, 36 % dissipated away by cooling water and general radiation, and 32 % carried away by the exhaust gases. If the heat loss to water jacket and general radiation can be eliminated, about 10 % to 15 % will be theoretically converted to useful work on the piston, bringing the percentage of total energy converted to work up by 10 % (allowing for losses due to increase of specific heat and dissociation at higher temperatures) to about 42 %, corresponding to an engine power increase of around 30 %. With the elimination of cooling system mechanical losses, a further increase on the original figure, of about 4% - 6% can be expected, bringing the total power increase to say between 33 % and 36 %. Since water heat loss and general radiation was eliminated with 10 % out of 42 % total energy converted to work, almost all the remaining heat, say 30 % can only be carried away by the exhaust gases, bring this figure from 32 % to 62%, an increase of 95 %. These figures suggest that the provision of an un-cooled engine would involve efficiency and power increases of somewhere between 28 % and 45%, and increase heat carried away by exhaust gases by 60% - 100%. Allowing for various factors, this would entail an increase of exhaust gas temperatures in the port from between 650°C and 1000°C to somewhere between 1000°C and 1400°C, with temperatures within an emissions reactor in the region of 1100°C To 1500°C. Average combustion volume surface temperature (typically adjacent cooling systems) would rise from those in conventional engines, at say between 150°C and 250°C currently, to between 750°C and 1250°C. An un-cooled engine could not therefore be constructed entirely in conventional metals, and alternatives are described below. It must be borne in mind that a projected power increase of 33 % to 36 % without increase in fuel consumption (none is required) must be considered a very valuable saving considering today's energy climate. Recent calculations indicate that un-cooled engines could provide even greater efficiency gains than those given here. Allowing for margins of error, an even 20 % fuel saving - a given power is necessary for a certain engine function, so fuel consumption would be saved rather than power increased - would make critical difference to the oil needs and political situation of a country such as the U.S.A.

Please amend the paragraph beginning on the last lines of page 10, as follows: (It corrects an error; silican carbide was meant to be cited as a good conductor.)

An exhaust gas reactor assembly mounted to or within an internal combustion engine may have incorporated within or adjacent to the reaction volume (whether associated with conventional or un-cooled engines) a heat exchanger, so that the heat of the exhaust gases may be used to heat the working fluid of an alternative engine cycle, either expending work on another engine or on the original (which thereby becomes a composite engine), or to heat fluid communicating with an electrical generator or an accumulator. Figure 4 shows diagrammatically such a configuration, where an engine 418 having exhaust ports 419 discharges exhaust gases 420 past finned members 421, having hollow passages shown dotted 422 communicating with lower linking passage 423 and upper linking passage 424 formed in reactor housing 425 and having access to, respectively, fluid entry

means 426 and fluid exit means 427. Such heat exchangers could be made of a material having high conductivity, including ceramics such as silicon carbide or perhaps silicon nitride or metals such as the nickel alloys, which may be such as to have catalytic effect. The heat exchanger may effectively constitute filamentary material, as described later. Alternatively, the heat exchangers may be placed elsewhere in the exhaust system of an engine, including just downstream of a reactor assembly.

Please amend the first full paragraph of page 15 as follows: (It is to repeat a description of feature 1010 made earlier in the paragraph.)

A selected embodiment of the engine is illustrated schematically in Figure 20. It consists of a piston 1001 reciprocating between two combustion chambers 1002 at each end of a cylinder 1003 closed by two heads 1004, with a crankshaft 1006 outboard each head, the piston being connected by tensile members 1007 to both crankshafts. Optionally, the crankshaft will also function as a camshaft, actuating valves and optionally providing fuel delivery. The liquid elements for the charge may be delivered to the combustion chambers under pressures and temperatures higher than normal in conventional engines. The cylinder is at least partially surrounded by an exhaust gas processing volume 1008, with exhaust gas being conducted to the volume by alternate paths 1005 and 1009. Intake to the combustion chamber is via the crankcase. Surrounding the engine is a heavily thermally insulated casing 1010, here functioning as structure enclosing volume 1008. This configuration is suitable for four and two stroke embodiments, consuming fuel ranging from gasoline and similar lightweight fuels through diesel and heavier oil fuels to coal and other slurries or powders. Any engine lubrication and / or bearing system may be employed, but optionally either gas or roller needle bearings are used, perhaps with water or other liquids, in the case of water preferably when the components are of ceramic material, as described later. The crank assembly is preferably so designed that any air bearings at least partially operate at a pressure equivalent to the charge pressure of forced induction, in the case of turbo-charged, supercharged or force-aspirated engines. In the case of two stroke engines, the preferred arrangement is to exhaust gases via ports about the center of the cylinder. In the two cycle form illustrated schematically in Figure 21, pressurized air is ducted via crankcase 1275 and valve 1276, actuated optionally by combined crankshaft / camshaft 1277, to combustion chamber 1288 (fuel injection system not shown), displacing exhaust gas which exits the chamber via ports 1289 to circumferential exhaust gas processing volume 1290. A heavily thermally insulating casing (~~Insulation~~) 1010 extends around the engine of Figure 20, and is shown around the crankcases and engine of Figure 21. In another example of either a two- or four-stroke engine, Figure 22, the schematically shown piston / cylinder module 1271 is linked to a single crankshaft 1272 by tensile elements 1273 routed about guides / bearings / rollers and / or wheels 1274.

Please amend the first full paragraph of page 31 as follows: (It serves to explain "blow-by".)

Blow-by occurs in all engines; it is the tubular column of gas that travels from the high-pressure combustion volume between piston and cylinder walls to a lower-pressure area below the piston. Experiments (by Timoney in Dublin in the 80's among others) have shown that a free piston, traveling at speed in a horizontal cylinder between two combustion chambers, does not make contact with the cylinder walls. It is supported by the high pressure gas blow-by, effectively a gas bearing.

<u>This is only possible in a case where there are negligible side loads on the piston, as above and with most of the embodiments disclosed herein. In conventional engines, the piston side loads are so great that piston rings and oil lubrication are required.</u> In engine designs where piston blow-by <u>speed</u> needs to be minimized, special piston grooves 1254 can be provided as shown in Figure <u>71</u>, wherein the piston 1243 is traveling in direction of arrow during compression. Correspondingly spaced depressions 1255 are provided in the cylinder 1244 wall, which if disposed uppermost will tend to be filled with inert exhaust gas rather than usable charge. It can be seen that, as the piston moves up the cylinder to compress the charge, that the pressure in the grooves will always be close to, but a little less than, the charge pressure at that time. Various pressure levels are shown by P1, P2, etc. It is known that the smaller the pressure differential between two gas reservoirs, the slower the rate of gas travel per unit mass between them. Therefore the rate of possible gas travel in piston / cylinder clearance space 1255 (the blow-by) will be reduced.

Please after the last paragraph on page 105 include an edited portion of the disclosure of 1974 and 1988, as follows:

The more suitable materials for general use fall into three categories: metals, ceramics and glasses, and giant molecules generally known as polymers. Broadly, metals are ductile, resistant to thermal and mechanical shock, strong with progressive weakening with increase in temperature, tolerably resistant to abrasion and corrosion, in their refined and alloyed forms fairly resistant to temperature, and substantially in their elemental form. The other two categories do not have the same broad spectrum of advantageous qualities; ceramics and glasses, which are generally oxides or compounds of the half-way elements, have superior qualities in all respects except ductility, resistance to shock and ease of working. However, because they are often very strong, more temperature resistant and generally much harder and abrasion/corrosion resistant than metals, great efforts have been made over the last decades to overcome their disadvantages. New manufacturing processes have been devised, the mixes have been blended to increase resistance to shock, and means of reinforcement developed. Concerning the polymers, these do not yet have the resistance to wear and temperature, or the hardness and strength of the materials, but they are beginning to be used as reinforcements and are also very suitable as insulating materials. They are capable of being the most elastomeric of the three groups and are useful for the manufacture of say the exhaust reservoir bellows of the invention, where temperatures are not as high as in the reactor. Polymers are being developed continuously; they are man-made and almost never occur freely in nature, and it is suspected that new super materials will be developed in the future by the polymerization of such metals as aluminum (next to silicon on the atomic scale) and some of the ceramic oxides. Many compounds do not fit clearly into one of these categories but lie in the area between.

Please amend the second complete paragraph of page 106 as follows: (Note: Alumina is cited elsewhere in the disclosure, including on pages 9 and 106,

Ceramics materials are especially suited to the manufacture <u>of the engine components generally, including</u> of the housings, inter-members and opening linings, because of their generally low thermal conductivity and ability to withstand high temperatures. Suitable material include

ceramics such as alumina, alumina-silicate, magnetite, cordierite, olivine, fosterite, graphite, silicon nitride; glass ceramics including such as lithium aluminum silicate, cordierite glass ceramic, "shrunken" glasses such as borosilicate and composites such as sialones, refractory borides, boron carbide, boron silicide, boron intride, etc. If thermal conductivity is desired, beryllium oxide and silicon carbide may be considered. These ceramics or glasses may be fiber or whisker reinforced with much the same material as metals, including carbon fiber, boron fiber, with alumina fibers constituting a practical reinforcement, especially in a high-alumina matrix (the expansion coefficients are the same). It is the very high alumina content ceramics which today might be considered overall the most suited and most available to be used in the invention generally. The ceramic or glass used in the invention may be surface hardened or treated in certain applications, as can metals and often using the same or similar materials, including the metal borides such as of titanium, zirconium and chromium, silicon, etc.

Please insert an edited section from the earlier 1974 and 1988 disclosures after the first full paragraph on page 107, as follows:

Wool, especially if of ceramic material, is often made by extruding or extracting fine jets of molten matter in a bath of cold fluid, usually liquid, a process which has been referred to previously as a fluid collision technique because of the force required and the rapid cooling on contact with the fluid. In a preferred embodiment, hot liquid filamentary material is injected through fine apertures, possibly arranged in the disposement of exhaust port layouts, into a restricted volume containing cold fluid which is of corresponding shape to reactor housing, the liquid on cooling forming into a wool mass of generally the shape to fit into reactor housing. If the wool or fibers are too linear in configuration, then the cooling liquid may be agitated say in a twisting irregular motion preferably by impeller forced into a cooling reservoir through an aperture corresponding to the exhaust gas exit.

The complex shapes that the filamentary material may comprise may be manufactured by a reversal process, whereby the forms of the intended passages are made up in material A, about which the filamentary material B is formed. Subsequently material A is dissolved or leached out in a suitable substance such as acid or water, leaving the material B only in the intended form. Such methods are known and suited to ceramic manufacture.

The materials may be formed by any of the current techniques now known, including slip forming, molding, pressing, stamping, sintering, extruding, etc. The isostatic pressing of powders is one of the more suitable means of manufacturing in ceramic the possibly complex shapes of the reactor housings, providing sufficient hydraulic pressure is available for the relatively large sizes of the objects. Pressing usually takes place on a male mandrel, which can accurately be made to the desired form. If the internal form entails difficulty of removal of product, then the male mandrel may be an elastomeric housing filled with an incompressible effectively fluid material such as liquid or powder or grains, these being removed after forming so that the mandrel may be collapsed inwardly.

AMENDMENTS TO CLAIMS

Please cancel dependent claims: 203, 217, 225, 227, 236, 238, 252, 282, 294, 326, 340, 352, 354, 365, 366, 370, 373 and 376, as set out in the attached schedules of all claims. (Total 18 cancelled dependent claims.) These were all "duplications" of a prior claim.

Please add dependent claims 377 through 396 (total 20 new dependent claims), as set out in the attached schedules of all claims. All these claims are virtually identical to other claims already in the case. It is intended that no further examination is required.

In multiple dependent claims 344 through 348, please amend the identity of the dependencies in each claim, as set out in the schedules of all claims. (The total number of dependencies is unchanged, at 48 over the five multiple dependent claims.)

In the claims, where it occurs, please delete the word 'housing' and substitute "casing", as set out in the attached schedules of all claims, to better relate to the terminology generally used in the disclosure.

Following inspection by the applicant, please amend independent claim 221 and dependent claim 299, as set out in the attached schedules of all claims, to overcome the possibility of statutory or non-statutory double patenting of claims in published patent 7 117 827.

Please amend independent claims 198, 221, 277, 321 and 349, as set out in the attached schedules of all claims, to overcome the several objections of the examiner. See also the Remarks below.

Please amend claims 207, 230, 256, 285 and 356, as set out in the attached schedules of all claims, to further distinguish over Gould plus Myers.

Please amend claims 278 and 322, as set out in the attached schedules of all claims, to further distinguish over Myers.

Please amend claims 202, 224, 226, 251, 281, 325, as set out in the attached schedules of all claims, to take into account the cancellation of their "duplicates".

Please make mostly minor adjustments to claims 206, 208, 231, 245, 246, 251, 255, 257, 286, 307, 308, 344, 345, 346, 347, 348, and 357, as set out in the attached schedules of all claims. These adjustments were to incorporate improved phrasing of the independent claims, to reflect new wording in the independent claims, to improve language generally, and to correct small errors.

Please amend claims 367 to 376 to correct an editing error, as set out in the attached schedules of all claims,

In none of the above cited changes to dependent claims was the subject matter of the claim changed.

As mentioned, an annotated version of all claims in the case, as amended herein, is attached.

A clean version of all claims in the case, as amended herein, is additionally attached.